THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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SATURN AND HIS SATELLITES.

EDWARD S. HOLDEN.

FOR THE MESSENGER.

Mr. Marth was good enough to call my attention to an interesting conjunction of Japetus on Nov. 8, at 17.8 P. S. T., which was observed here as follows:

At 15*h* 34*m* P. S. T. the double distance of Japetus east of the center of Saturn, measured in the direction of the major axis, was 8″.22 (6), or the distance was 4″.11. At 15*h* 49*m* the position angle of Japetus from the center of Saturn was 7°.0 (5).

At 15*h* 10*m* Mimas was the only satellite not visible; Enceladus being plainly seen just *n. f.* the following and north limb of the planet and almost half as bright as Japetus. At the same time Tethys was more than twice as bright as Japetus. At 15.7*h* Enceladus was no longer visible, being about 7.4*h* past elongation. Under the best circumstances I think this satellite can even now be followed completely round its orbit.

Since October 22 Saturn has been viewed here on every suitable night (about fifteen nights), usually by Professor Schaeberle and myself. The following notes of observation may have some interest, although subsequent observations may modify them:

The Ball.—At the south pole there is an extremely narrow brighter polar cap. Its dimensions parallel to the equator are about 5″, and perpendicular to this about the width of the Cassini division at the ansæ. It has been seen by Mr. Schaeberle on several occasions, but I have been sure of it only once, namely, on the very perfect night of November 10, when the seeing was strictly first-class, and when the estimates of its size, just given, were made. It is bordered on the north by a very narrow belt, which is notably darker

than the dark olive-green hue of the southern hemisphere. On the southern hemisphere there is one narrow, bright belt south of the equatorial belt from which it is separated by a narrow dark band, not uniform in color, but broken into whitish clouds over a rosy background as in M. Trouvelot's Harvard College drawing of 1874. There are also two brighter narrow bands south of this. Next north of the bright equatorial belt is the dusky ring, the ring system (B and A), and finally the northern hemisphere, whic [illegible] materially brighter than any part of Ring A. There also seems to be a faint dusky belt just south of the dusky ring, and it is curious to note that the ends of this belt, where they meet the two limbs of the ball, are spread out (parallel to the minor axis) apparently more than perspective requires.

Shadow of Ball on Ring.—In good seeing this is always *concave* to the center of the ball and of a uniform curvature. Nothing whatever can be seen inside of this shadow.

Shadow of Rings on Ball.—This has always appeared, both to Mr. Schaeberle and myself, even in the best conditions, slightly wider north and south, at the preceding than at the following end.

Ring B.—This is shaded as in M. Trouvelot's well-known drawing, except that it appears to the eye perfectly flat, whereas the drawing gives a slight curvature to the surface. In front of the ball the shading is also seen, and here it gives the appearance of a rounded surface. The lines of division between the various shaded zones are fairly sharp. The line of division between B and C is perfectly definite and sharp, more so than in any recent drawing that we have seen, except one by Mr Keeler with this telescope.

Ring A.—This ring is notably less bright than B, and is gray in color. The Encke "division" has not yet appeared to Mr. Schaeberle or to me as a true *division*, but rather as a shading better defined on its outer edge than at its inner. This shading is now seen about two-fifths of the width of Ring A from the outer edge. We have so far seen no sign of the division in Ring A, shown in the drawing by Mr. Keeler in THE SIDEREAL MESSENGER, February, 1888, page 81. This division cut off a narrow zone from the outer part of Ring A, about one-fifth of the width of this ring, and this zone was represented as much brighter than the rest of Ring

A. Under the best circumstances of vision (only) I have seen such a zone, with less contrast of brightness, however, than as figured in the drawing referred to.

The Cassini division appears to be perfectly black and bounded by smooth curves.

I have been forcibly struck by the analogy between Ring A and Ring B. Both appear to have brighter exterior zones and to be shaded in similar ways. I think observers may aid their conceptions of the appearances on Ring A if they will consider whether Ring B would not present similar ones were it materially reduced in brightness.

Dusky Ring (*C*).—So far this ring has always appeared uniform in texture, and essentially so in color. The edge towards Ring B is sharply terminated, and the inner edge has always appeared to me to be uniform. I have so far seen no dark patches, etc., etc., on this ring with certainty. The color is a reddish brown, or a grayish red. At Washington with the 26-inch equatorial it has always appeared to me more vivid and sparkling in tone, and more violet in hue.

This difference in color I attribute to the difference in color corrections of the two telescopes. The secondary spectrum is less obnoxious here, and there is no diffused ghost from the object glass.

Satellites.—Titan has a reddish yellow disc, and shines with a mild light quite different from that of a star of the same magnitude. Enceladus, Tethys, Dione and Rhea are bluer and more stellar in appearance. On Nov. 9 Japetus was slightly fainter than Dione and Tethys, on Nov. 10 a little fainter than Rhea, and on Nov. 11 nearly twice as bright as the latter satellite.

THE NEW MERIDIAN CIRCLE AT CINCINNATI OBSERVATORY

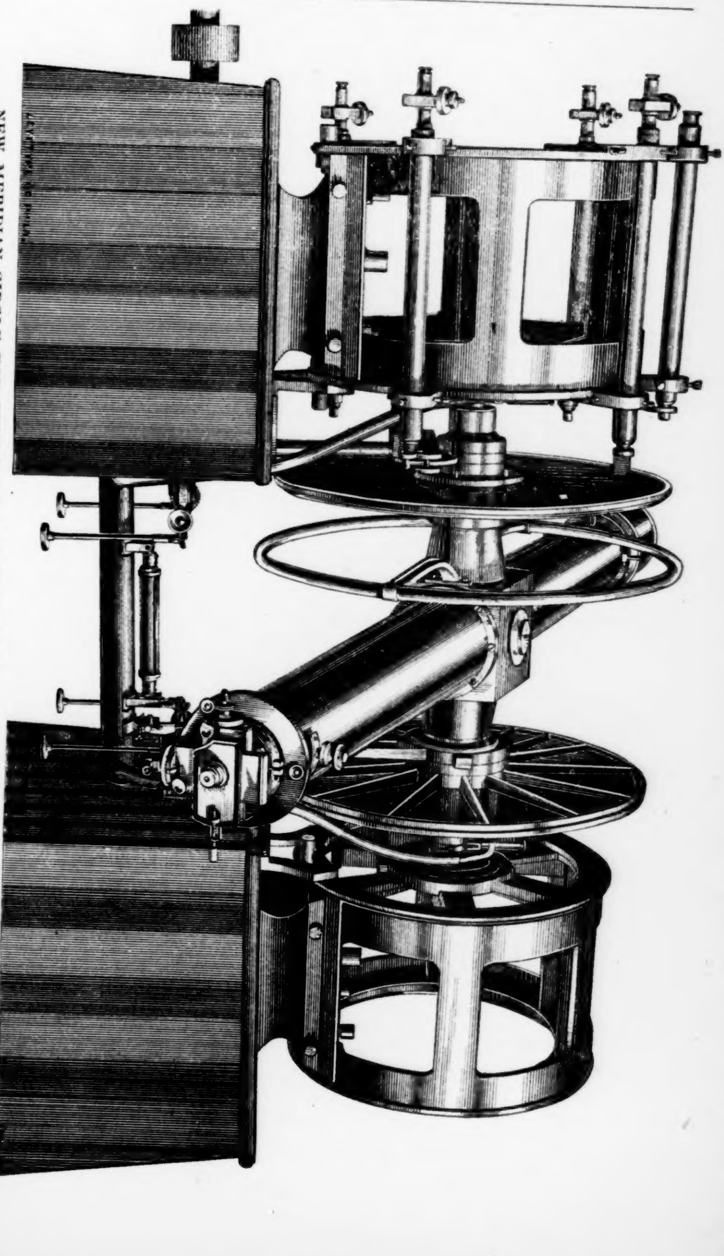
J. G. PORTER, DIRECTOR.

For THE MESSENGER.

The new Meridian Circle, constructed for the Cincinnati Observatory by Fauth & Co. of Washington, was placed in position on the first of September. As this instrument embodies several of the latest improvements in construction, and is in all respects a first-class piece of workmanship, a brief description of it may interest the readers of THE SIDEREAL MESSENGER.

The clear aperture of the object glass is five and one-eighth inches, and the focal length seventy inches. The instrument rests on two iron piers which are placed directly on the large masonry pier built even with the floor of the observing room. These iron piers are bricked up solid inside to within one foot of the top, leaving room only for the counterpoise weights, and the whole is then completely encased with wood. In point of stability stone piers may be preferable; but the counterpoises must be placed above the axis, where they are both unsightly and much more in the way when the instrument is reversed. In the description of Washburn Meridian Circle, which is slightly smaller than ours, Professor Holden states that five minutes is about the shortest time in which two persons can safely reverse it. One person can easily and safely reverse the Cincinnati instrument in about three minutes. To the top of the piers two iron plates are bolted. Into each of these three glass-hard steel plugs are inserted upon which the three leveling screws of the microscope holders rest. By suitable opposing screws the microscope holders can also be shifted east and west or north and south. The counterpoise levers are carried by arms which project from the microscope holders downward through openings in the top plates inside the piers.

The telescope itself does not differ materially from the Repsold type. The pivots are of steel, glass-hard. The object-glass and micrometer can be interchanged. The cell of the objective is steel, and the lens is supported at three points, one of the chucks being movable and pressed inward by a spring in such a way that changes of temperature will affect the collimation only and not the nadir point. The micrometer is fitted with a glass reticule. The horizontal lines are about 10″ apart. In observation the star is brought midway between them. The right ascension micrometer carries the glass reticule, so that the collimation can always be set at zero. A declination micrometer is also provided carrying a single spider line. The neat method of indicating whole turns by a separate dial is applied to both micrometers. For focusing a key with milled head is used, fitting into an opening in the side of the telescope. When the focus is satisfactory the key is removed and the aperture



NEW MERIDIAN CIRCLE FOR CINCINNATI OBSERVATORY, BY MESSRS. FAUTH & CO., WASHINGTON, D. C.

covered with a cap. The whole micrometer can also be turned around the optical axis to correct for inclination of the lines. The movement of the eye-piece across the field of view is effected by a screw of steep pitch with a small octagonal head which turns very easily between the fingers. Motion in either right ascension or declination can be given by simply turning the plate which carries the eye-piece ninety degrees.

The telescope carries two circles of twenty-four inches diameter. One is divided very coarsely to half degrees only; the other has two sets of graduation upon a silver band, both of them to five minutes of arc. The inner one is somewhat heavier than the other, and does not pretend to great accuracy. It is numbered to every degree, and is used merely for setting. The outer graduation alone is visible in the reading microscopes. Several sets of observations have been made for testing the accuracy of the graduation. The method employed was to compare the mean of the reading of two opposite microscopes with the mean of the reading of the other two. This difference should, of course, be constant were there no other source of error than eccentricity. Each of the sets disclosed a periodic error which can be represented under the form $1''.5 \sin(2z-z_0)$, z being the reading of the initial microscope, and z_0 a fixed angle. This term disappears when the mean of the four microscopes is taken. The residual errors, after the application of this term, are very small, one second of arc being about the limit. For a twenty-four-inch circle this is certainly fine work. Professor Hall, of the Naval Observatory, has suggested that, since the ten degree marks were put in first and the dividing engine run from one of these marks to the next and then adjusted if necessary, the errors would naturally show most by comparing the divisions at 9° and 11°, 19° and 21°, etc. I have accordingly commenced an examination of this kind, but as yet no errors have been found which much exceed the limit already stated.

The circles are clamped to the axis after the Repsold fashion, and can be moved into any position. They are solid, with strengthening spokes upon the back. With circles of this size the flexure should be insignificant. Fastened by means of two arms directly to the cube of the telescope is a

nickel-plated ring a little larger than the circles. Standing at the setting microscope one can readily reach the ring and revolve the telescope. As the field of this microscope is large, and at least one whole degree division is always in view, the setting can be done with great rapidity and ease.

The illumination of the circle is by means of small electric lamps, and is practically perfect. These lamps are placed at the end of each microscope and can be lighted in succession by turning a switch. The illumination of the field is also effected by an electric lamp, and a small hand lamp which can be lighted by pressing a spring is used for reading the micrometers. Thus no oil lamps at all are needed, though the instrument is so arranged that oil illumination can be used if desired. The intensity of the field illumination is controlled by turning a milled head near the eye end. Many stars of the ninth magnitude have already been observed, and it will probably be possible to get those of half a magnitude fainter. Of course, for very faint objects a spider line reticule is to be preferred.

With the instrument the makers furnish a reversing carriage, an observing chair of neat pattern and a hanging level. This latter is quite heavy, but it has a device which prevents the V's resting on the pivots with the full weight.

On the whole, the points about the instrument to be criticised are few and unimportant. Such slight changes as the writer might suggest would possibly not suit others as well as the present arrangements. It is certainly pleasant for Americans to feel that even in such matters as instrument making and observatory equipment they are scarcely behind the most renowned firms of the old world.

MR. BRASHEAR'S EUROPEAN VISIT.*

FOR THE MESSENGER.

I had not the good fortune to spend an evening in any of the Swiss observatories though I paid an early morning visit to the prettily situated observatory at Geneva. While at Chamounix we had several days of beautiful weather, and I longed to make some observations in that far-off land. I found a very excellent 4-inch telescope by Secretan in the

* Continued from page 391, No. 69.

village and leased it at a pretty high figure for a few hours' work. Observations were made on Jupiter and some double stars, but as the telescope was only provided with a low power, the observations were not of much value; but I noted that there was very considerable disturbance in the atmosphere, probably due to the rapid change of temperature common to the summer nights in the Alpine mountains and valleys.

Hastening on to Munich, the home of Frauenhofer, of Merz and Mahler, of Ertel, of Steinheil and many others who have done so much for astronomical science, we found a hearty welcome in that city of art and science. This being the Bavarian jubilee year, and there being a great exposition at Munich it was a good time to be there, and I had the pleasure of meeting an old artist friend who knew Munich so well from several years' residence that our stay was doubly pleasant and profitable.

The Bavarians have not forgotten Frauenhofer, he being among the honored ones of the great jubilee. I had been there but a day when my friend suggested we visit a house which the Bavarians hold as almost sacred. It was found in a very narrow alley near the center of the city. The surroundings were very old fashioned and certainly, from an artistic point of view, not very inviting. At a distance of perhaps six feet from the pavement were these words inscribed on a tablet imbedded in the cement of the walls:

"Bei einsturz dieses
Hauses im 1801 wurde
der Glaser Lehrling und
Später so beruhinte
Mechanicker und Optiker
Frauenhofer verschüttet
und wunderbar gerettet."

which being translated would read about this way: Upon the falling of these houses in 1801 the honored glazier's apprentice, and afterwards the celebrated mechanic and optician, Frauenhofer was miraculously saved. It was an interesting spot to me, not made so by its architectural beauty or its surroundings, but because it was the early home of one whose labors in after life advanced in so marked a degree our knowledge of optical science. I didn't bring many relics home with me, but I could not resist the temptation

to dig a few pebbles from the walls of the old house, once the home of Frauenhofer. The works of Steinheil and Sohn were visited, but at the time of my call they were not working, though I was shown around their place from which so much good work has come. The old firm of Ertel & Son were engaged principally on transit work, and I had much pleasure in examining their dividing engine. Mr. Ertel showed me an engine that he had experimented on for many years for making gratings, but it never came up to his expectations. He made a remark to me that was very pleasant to hear, which was that he would rather do work for American astronomers than for any other in the world, and then gave me the reasons, which summed up in brief were that the American astronomer *knew what he wanted, ordered it, and paid for it when he got it.* Reinfelder and Hertel do some very fine work in oculars, prisms, spectroscopes, etc., and at the time of my visit were making a nine-inch objective, and, to be certain of producing a first-class instrument, they were working too. That would seem a queer proceeding in this country.

They make a fine wide field negative eye-piece giving a beautifully clear and flat field; but the lowest powers show "ghosts" when a bright object is being observed which, of course, can be eliminated in the "mind's eye." From Munich we went to Leipzig, where a delightful day was spent with Dr. Victor Schumann who is doing, perhaps, the finest work of the kind in Europe. He is working principally in photographing the spectrum of the gases, and his work has been mostly in the ultra violet. I have never seen a more thoroughly equipped private laboratory; and the neatness and perfect system in every department was most delightful to witness. The Doctor has a battery of eighteen quartz prisms for work in the ultra violet as well as two fine diffraction gratings. I could fill many pages descriptive of Dr. Schumann's apparatus, but I will only say that he has taken perhaps 2,000 spectrum photographs, all of which are arranged for quick reference, and some of which are most remarkable. I will refer to but one, namely, a photogaph in the ultra violet of the spectrum of nitrogen, in which I counted a symmetrical series of triplets, twelve in number, the individual lines of which were clear and sharply

defined in the negative. I am sorry I have forgotten the wave lengths, but these symmetrical or harmonic series are characteristic of the spectrum of nitrogen as may be seen in Dr. Hasselburg's beautiful maps of this gas, particularly at wave lengths 442 *et seq.*, 45 *et seq.*, and 473 *et seq.*

But I must not dwell longer in this charming laboratory, much as I enjoy it. Dr. Schumann is doing a splendid work, and none know it better than his German co-workers.

The Astrophysical Observatory of Potsdam was our next objective point, and hither we went the day after leaving Leipzig. Drs. Vogel and Lohse were off on their vacation but we were offered every facility to study the many interesting instruments of this great Observatoy. A magnificent spectrometer has just been completed by Bomberg, of Berlin, for the Observatory, that has many new features. I might mention that the objectives of 2½ inches aperture are of the new "Abbe" glass made in Jena, and they are certainly beautiful specimens of the optician's art; the corrections are fine, and if the physical properties of the glass turn out equal to the optical characteristics, we will have great hopes for the future of it. Another feature of the instrument is that the circle has its graduations on the *under* side and are read by "broken" microscopes with great ease. When the observing telescope arm comes around, it would strike the upward projection of the microscopes if they remained *in situ*; but an ingenious device drops whichever one comes in its way, and immediately resets it when it has passed over it.

The solar photographic instrument of this Observatory is constructed upon the plan of Sir Howard Grubb's "siderostatic" telescope, *i. e.* the tube is the polar axis of the instrument, the objective being at the bottom of the tube. Below the objective is a flat mirror, which may readily be adjusted to throw the solar image in the axial line of the objective. Only the mirror need be exposed, and for solar photographic work I should think this instrument would be very effective. As much of the work in this grand institution is in the nature of laboratory work, the roofs of the buildings are covered with soil and a beautiful growth of lawn grass covered it at the time of my visit. One lingers in such a place, unwilling to leave it, with its pleasant peo-

ple and grand work, but we *had* to go, willing or not. Hamburg we had long wished to visit. The name of Repsold has had an enchantment to us for years. Housed up in a city for nearly all our life time where we could see nothing of that higher class work that was always our ideal, it was a grand day for me when I set foot in old Hamburg. The very first day I met at dinner Dr. Neumayer, of the Hamburg "Seewarte," who introduced me to Dr. Mach, of Prague, Dr. Rumker, of the Astronomical Observatory, and here I also met Dr. Luther, so you see I found many genial spirits, and, what was more, they could talk English, which was a great boon to me.

The Hamburg Seewarte is perhaps the most complete institution of the kind in the world, and the courteous director, Dr. Neumayer, is known among all nationalities. There were thirty-five assistants in the different departments, and every department, such as the meteorological, was most thoroughly equipped with the most perfect instrumental means. In the center of the great building is erected the great whirling table for the study of the anemometer constants, and which was used not long since for a study of "aeroplanes" by a member of the French Aeronautical Society. Every device for deep sea soundings, in fact almost every nautical appliance, fills the interesting museum of the Observatory. They have their own corps of lithographers and draughtsmen, and the records thus kept and preserved for reference fill many hundred quarto volumes. These are always available to captains of vessels from any part of the world. Dr. Neumayer is the originator of the south polar expedition for the benefit of meteorological science. He is a grand fellow, and did everything in his power to make my stay in Hamburg pleasant. Dr. Rumker of the Astronomical Observatory has not been well, and Dr. Luther has been assisting him during the past summer. There are some fine meridian instruments in this Observatory, one of them the work of the grandfather of the present Repsolds, and of course it goes without saying that the grade of the instrument is very high.

A pleasant ride out into the suburbs brought me to an unostentatious building, on the doorway of which was a brass name plate about the size of a page of the MESSENGER, with

the modest inscription "A. Repsold and Sohn," engraved upon it. I found both of the gentlemen "at home" and they gave me several hours of their valuable time, and much as I felt I was inposing on good nature in staying so long as I did, I could not but feel that I was welcome. Fortunately for me they had just finished one of their beautiful heliometers, a description of which was accorded me, and it may interest you to say a word about the driving clock. The form of clock now used by the Repsolds, they claim *does not need any electric control from the sidereal clock for photographic or any other accurate work.* I saw one attached to the photographic telescope at the Astrophysical Observatory at Potsdam, and was informed that its work was perfectly satisfactory to them. Briefly stated the principle is this; a rod of steel, say 15 inches long, ⅜ inches in diameter at the lower end, tapering to ⅛ of an inch at the top, is fastened securely at its base; *i. e.* not pivoted in any way. Near the top of this steel rod a weight of perhaps five pounds is secured at the proper point, but is adjustable up and down. A slotted crank extends horizontally from a vertical rapid movement axis of the driving clock, the upper end of the rod just spoken of extending up into the slot of the crank. As this crank is not slotted to the centre, it is evident that when it is set in rapid motion, the centrifugal energy of the rotating weight tends to throw it out to a certain distance, due partly to the position of the weight on the rod; but when this position is fixed at any one point the *elasticity* of the rod, which constantly tends to bring it to a vertical position, regulates the speed to a high degree of accuracy.

It may at once be seen that this is not a friction-controlled clock, and as it is so simple in its workings, so easily constructed, I am sanguine that it will rank high as a regulator for driving clocks. While the invention was original with the Messrs. Repsold, they laughingly informed me that they learned that a Yankee had applied it to regulating a Morse telegraph machine *twenty years ago.* I had the rare pleasure of an examination of the world-renowned dividing engine of Messrs. Repsold, as well as the smaller one which is largely used for the smaller work. It would occupy too much of your time to even run over the salient features of

the dividing engine. It has come through three generations and stands to-day unrivaled in the excellence of its work. Of course it is known that the engine is not automatic, but every individual line is set with a high-power microscope, or several of them, as the accurcy of the work demands.

It may also be interesting to know that Messrs. Repsold make all their drawings to full size. Even the largest telescope has every part made full size. No tracings or blueprints are made, and, what may seem remarkable, no figures are marked on the drawings. The workmen must take all the measurements from the full sized drawings, and I was told that few errors are made. But the brothers Repsold have a personal superintendence over everything, and I need not speak of the results. Every astronomer knows that what they do is well done.

There was such a genuine spirit of unselfishness with these people that I came away a thousand times repaid for my visit, and, as was the case in Paris, I left Hamburg with feelings of deep regret, hoping to have the privilege of going again before my humble share of the world's work is done. I know I have exceeded the limits of propriety in this letter, so I must leave my visit to Hilger, Sir W. Thompson's laboratory, and the works of Sir Howard Grubb until I write again.

MARS AND HIS CANALS.*

H. C. WILSON, PH. D.†

When we examine the disk of the planet Mars with a telescope of sufficient power, we find it to be diversified by dark and light markings, of definite form and permanent character, which we have been accustomed to interpret as evidence of land and water, continents and oceans, similar to those which exist upon the surface of the earth. In this respect Mars differs from all the other planets. Mercury and Venus show no permanent markings whatever. They appear to be completely enveloped in perpetual clouds. Jupiter and Saturn, it is true, have their dark-colored belts, which are more or less permanent, but the arrangement of these par-

* A paper read before the Cosmos Club of Northfield, Minn., Nov. 23, 1888.

† Assistant Professor of Astronomy at Carleton College Observatory.

allel to the equators of the planets indicates that they are due to currents which are produced in the dense vaporous envelopes by the swift rotation of the planets. Uranus and Neptune are too distant to admit of accurate delineation of their surfaces, but what little has been done with two or three of the most powerful telescopes in existence indicates that they are, like Jupiter and Saturn, enveloped in clouds with colored belts parallel to their equators. It seems singular, as the late Mr. Proctor said eighteen years ago, in "Other Worlds Than Ours," that "among all the orbs which circle around the sun, one only, and that almost the least of the primary planets, should exhibit clearly and unmistakably the signs which mark a planet as the abode of life."

Mars alone presents appearances which we may, with any degree of certainty, ascribe to the presence of continents and oceans, islands and seas, like those upon our own planet. Upon Mars alone do we see indications of changes of seasons, winter and summer, rain and snow, like those which we experience. These facts lend a special interest to this planet which attaches to none of the others, and lead us to speculate as to the kind of inhabitants there may be upon that far-away world, and what they are doing; whether they are like ourselves. Are they devoted to science? Are they constructing immense telescopes and gazing at us, making maps of the Atlantic and Pacific Oceans and the eastern and western continents? Do they know whether, at the north pole of the earth, there is an open sea, or whether there is an undiscovered continent near the south pole? Are they a race of great engineers, and do they construct public works on a gigantic scale? This last question is suggested by my subject, "The Canals of Mars," which have added so much of interest to the planet during the last few years.

I place before you a chart* of the planet Mars, a copy of one constructed by Mr. Proctor from a large number of drawings made by that keen-sighted English astronomer, Dawes, in September, 1864 and 1865. This chart is on the stereographic projection and is inverted,—the south polar regions, that is, are at the top,—because the telescopes com-

* This chart may be found in Proctor's "Other Worlds than Ours" and in some of the later text books on elementary astronomy.

monly used by observers exhibit inverted views of the celestial objects. It is not accurate in its details, but shows very faithfully the outlines of the most prominent features, and gives the general appearance of what can be ordinarily seen with a telescope of moderate power. The darker parts are a dusky green or blue color and are supposed to be seas. The reddish tracts are supposed to be land. Both the dark and the reddish tracts are frequently seen to be covered with areas of white, either clouds or snow. I notice that Professor Holden, in his report of observations made this summer with the great Lick telescope, speaks of some parts of the continents as bright yellow. I presume that we may attribute both the red and yellow colors to different conditions of the Martial vegetation.

At the top of the map we see the region of ice and snow, which lies at the southern pole. Around that is a sea which is unnamed in the map. Then comes the south temperate zone with several tracts of land named after Cassini, Lockyer and other astronomers. In later and more accurate maps these are represented as islands. The coast line beyond them is not often distinctly seen. Below this zone the features are more distinct and easily recognized. First there is an almost continuous belt of water, Maraldi Sea, Hooke Sea, Dawes Ocean, Arago and Herschel Straits surrounding Phillips Island and connecting Dawes Ocean with Delarue Sea. Next the equatorial belt of four great continents, Herschel, Dawes, Mädler, and Secchi, separated only by straits and seas. Kaiser Sea, between the first two continents, is the darkest and most easily recognized marking on the disc of Mars. Below these continents is a narrow belt of water completely encircling the planet, then a narrow strip of land, La Place Land, then a narrow sea surrounds the north polar ice cap. These two polar caps are always brilliantly white, and sometimes appear, because of irradiation of light, to project beyond the edge of the disc.

The more prominent of these features of Mars' surface were noticed over two hundred years ago. Cassini, with one of those outrageously long telescopes which were used before the invention of achromatic refractors, was the first to discover that they were of a permanent character, but Hooke, an English astronomer, obtained better views of the

planet as early as 1666. Since then a host of eminent astronomers, among them the Herschels, Arago, Secchi, Beer and Mädler, Nasmyth and Jacob, Delarue and Phillips, Lockyer and Dawes, have thought the study of Mars' surface worthy of a considerable portion of their time. Within the past few years this work has been prosecuted by a number of enthusiastic and careful observers, among them Burton and Boeddicker in Ireland, Knobel, Denning, Green and Maunder in England, Terby and Trouvelot in France, Perrotin and Schiaparelli in Italy, and we have for part of the past opposition and for the future to add the names of the observers who are permitted to use the great Lick telescope in America—Holden, Keeler and others.

Up to 1877 the observers appear to have confined themselves chiefly to delineating the outlines and variation of tint of the dark areas which immediately strike the eye when one examines the disc of Mars with a telescope of sufficient power, and to have neglected to examine carefully and persistently the bright reddish areas. During the opposition of 1877, which was exceptionally favorable, Mars being at its nearest approach to the sun and to the earth at the same time, M. Schiaparelli, the director of the Observatory at Milan, had the happy inspiration to concentrate his attention upon the great brilliant areas of the continents, in order to study their minutest details. He was rewarded by a brilliant discovery, of details so numerous and surprising in character that many astronomers are still, after the lapse of twelve years, incredulous of their reality. It was no less than a perfect network of very narrow dark lines, mostly straight, running across the continents in all directions, connecting the seas. To these Professor Schiaparelli gave the name of "canals," because, I suppose, of their straightness and from the fact of their connecting the seas. In 1879 he again saw the canals of 1877 and several new ones. No one else was able to see them, although many observers were provided with more powerful telescopes. Two or three saw some narrow markings on the planet, but it was not certain that these were the same that Schiaparelli had seen. During the opposition of 1881-82 Schiaparelli, following up his wonderful discoveries, struck a last blow to the confidence of the astronomers who hesitated to follow him; this time

the canals appeared almost all to be double. A new canal appeared beside the old one, rigorously parallel in most cases, and starting, not from the same point of origin as if the old canal were simply divided into two component canals, but from a different point, as if a new canal had really been formed parallel to the first.

I have prepared a copy of a chart of Mars constructed by Professor Schiaparelli, from his observations made in 1882 and 1886, upon which you can see the network of fine lines, the canals, crossing the continents from sea to sea in all directions. They are somewhat exaggerated in distinctness in the drawing, so that you may see them with ease. This chart (Fig. 1) is upon what is called Mercator's projection, the regions near the poles being distorted out of all proportion, but the equatorial regions represented accurately.

Will you compare the lines of the chart with Schiaparelli's own words of description:

"These lines [the so-called canals] run from one to another of the dark spots of Mars, usually called *seas*, and form a very well-marked network over the bright part of the surface. Their arrangement seems constant and permanent (at least so far as can be judged by the observations of four and one-half years); but their appearance and the degree of their visibility is not always the same, depending on circumstances which we cannot at present discuss with full certainty. In 1879 many appeared which had not been seen in 1877 and in 1881–1882 all those which had been seen the first time were re-discovered, and other new lines as well. Their number could not be estimated as less than 60. Sometimes these lines or canals show themselves under the form of diffused and indistinct shading; at other times they appear as very definite and precise markings of uniform tone, as if they had been drawn with a pen. In most instances their curvature differs very little from a great circle, if indeed it does differ; some others however are much curved. The breadth of the finest can hardly be estimated at less than 2° [70 miles] of a great circle but in some cases it reaches to about 4°. As to the length, that of the shortest is certainly less than 10°, others extend to 70° and 80°. The color is sometimes as dark as in the seas of Mars, but often it is brighter. Each canal terminates at its two extremities either in a sea or in another canal. I know of no instance where one end remains isolated in the midst of one of the bright areas of the surface without resting on lines and dark spaces.

"Now in many of these lines it has fallen to me to observe the curious and unexpected circumstance of a doubling or reduplication; this happens in the following manner: To the right or left of a pre-existing line, which suffers no change from its previous direction or position, another line appears, nearly equal to the first and parallel to it; in some instances a slight difference of appearance being visible and sometimes also a slight divergence of direction. The distances between the pairs of lines formed in this

manner varies from 6° to 12° of a great circle; there were also other lines which I suspected to be doubled, but the distance being less than 5° or 6° the telescope did not succeed in resolving them, and showed in that place a large, broad, and somewhat confused stripe. Sometimes a line is divided by another which intersects it into two districts or sections of unequal darkness and extent; in this case the companion line is divided into two sections in the very same way, with one exception no sensible irregularity of direction or of shape could be ascertained with the power used in these observations, which was always one of 417. Some of the pairs show so great a regularity that one would say that they were systems of parallel lines drawn by rule and compass. Perhaps however this regularity will not resist the use of a high magnifying power. In various instances, pairs are so connected the one with the other as to form a polygon of double lines with very pronounced angles, and such a series then occupies a great space. Two pairs sometimes cut each other without being interrupted; meeting then three by three they form at the points of triple intersection a network of which our telescope could only give an exact and complete resolution in one or two cases.

"Excluding those cases not well ascertained through the inability of the instrument to resolve objects so minute, the number of reduplications I observed in the last opposition is 20, of which 17 had been established in the course of one month, from January 19 to February 19, the mean date corresponding very nearly to the end of the second month after the vernal equinox of the planet. The phenomenon seems to be confined to a definite epoch, and it appears as if it took place simultaneously over the whole planet's surface occupied by the bright areas. No trace could be ascertained in 1877 during the weeks which preceded or immediately followed the southern solstice of the planet. Only one isolated case presented itself in 1879, between December 24 and 26, and this was exactly reproduced under similar circumstances between January 11 and 12, 1882; it took place in the two lines named Nile I and Nile II on my chart of 1879. Both of these two epochs being close to the vernal equinox of Mars there is ground for believing that the phenomena of reduplication may be periodical, and perhaps connected with the position of the sun with respect to the axis of rotation of the planet."*

When Schiaparelli's chart for 1882 was published it was received with incredulity and almost ridicule, by many. This was due in part no doubt to a fault in the engraving of the chart, which made the lines of the canals and the outlines of all the markings of the planet hard and unnatural, quite unlike the actual appearance in the telescope. But if you will compare the two charts you will see how difficult it is to reconcile the features of the one with those of the other. The different method of projection and the addition of so many new features, all exaggerated in distinctness,

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* *The Observatory*, Vol. V, pp. 221-224.

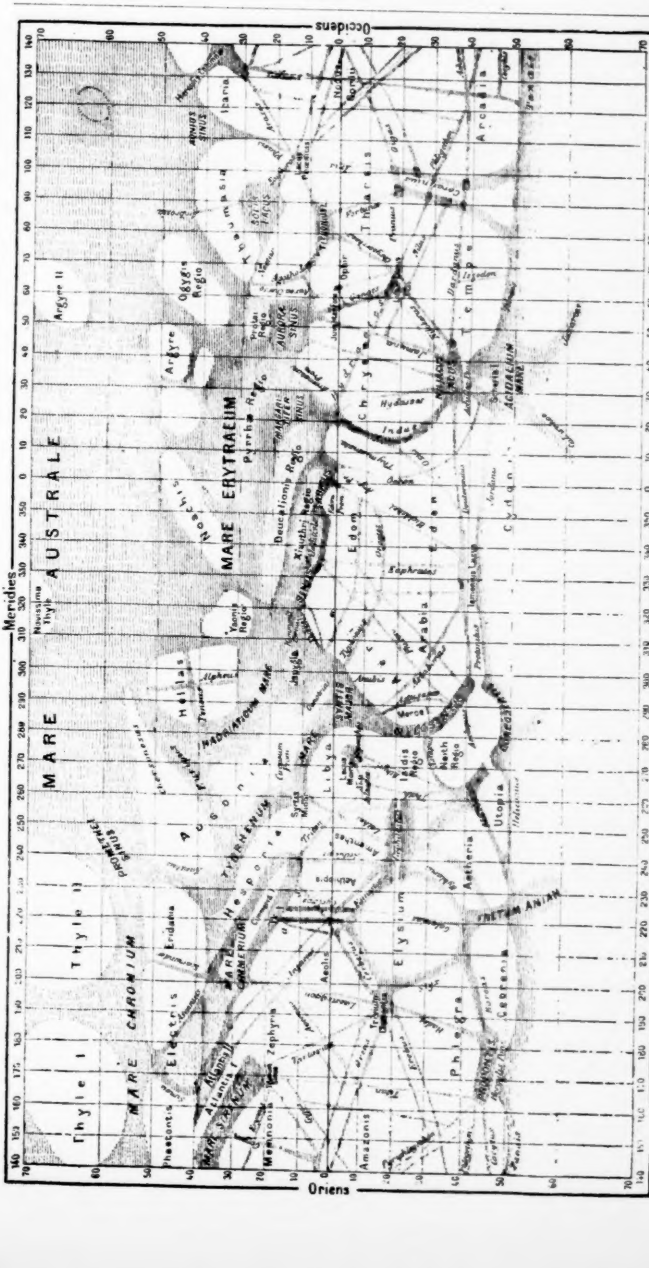

FIG. 1.—SCHIAPARELLI'S CHART OF MARS FROM OBSERVATIONS IN 1882 AND 1886, Copied from *L'Astronomie*.

renders the whole aspect unfamiliar. Yet if one will start with a prominent marking as, for instance, Kaiser Sea (Syrtis Major), and follow the coast lines, he will find nearly every feature of the Proctor chart upon that of Schiaparelli and in its proper place. Perhaps the greatest differences apply to the long narrow inlets of Nasmyth, Bessel and Huggins. These are replaced on Schiaparelli's chart by narrow canals or pairs of canals (Protonibus, Ceraunus, Iris and Gigas). In fact if we examine the original drawings of Dawes we find that the appearance of these features corresponds very much more closely with the chart of Schiaparelli than with that of Proctor.

Up to 1886 no certain confirmation of the duplication of the canals or of their existence was obtained by any other astronomer, but in that year Professor Perrotin of the Observatory of Nice, succeeded with a 15-inch telescope in detecting fifteen of them, and witnessed also the duplication of several. It will give one an idea of the difficulty of seeing these objects, to know that Professor Perrotin, armed with so powerful an instrument, at first gave up the attempt after several days' fruitless effort; having renewed his trials still without success, he was about to give them up finally, when he succeeded in seeing the canal Phison which crosses Dawes continent.

During the present year both Perrotin and Schiaparelli were provided with still more powerful instruments, the latter with an 18-inch and the formei with a 30-inch refractor, and the results obtained from the study of Mars' surface go to completely confirm Schiaparelli's discoveries. Several drawings of the planet by these two gentlemen have been published in recent periodicals and I have copied two of them for your benefit. The lower on the left hand (Fig. 2) is by Schiaparelli, from sketches made on June 2, 4 and 6. The most prominent marking near the center is easily recognized as Kaiser Sea (Syrtis Major and Nilosyrtis) of the chart. On the right is the curious forked bay of Dawes. The canals of the equatorial regions are drawn very much as they appear in the chart. Some old ones are omitted while several new appear. This (Astaboras) is straight and double instead of curved and single as in the chart. It is not really a separation of the old canal into two, but a new canal is seen start-

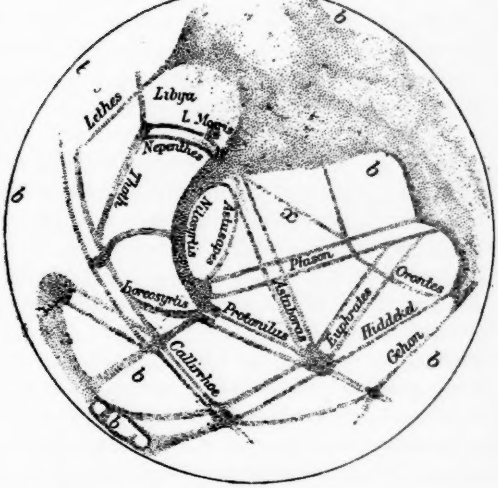

FIG. 2.—MARS, from drawings by Schiaparelli, with the 18-inch refractor at Milan, June 2, 4 and 6, 1888. From *Ciel et Terre*, Aug. 1, 1888.

FIG. 3.—MARS, from drawings by Perrotin, with the 30-inch refractor at Nice, June 4, 1888. From *Ciel et Terre*, Aug. 16, 1888.

ing from a different point of Kaiser Sea, and running parallel to the old one to a different point of the lake (Ismenius). The greatest difference is in the regions around the north pole. The system of canals is extended right up to the polar cap, and we notice across the ice cap itself two dusky streaks. This opposition was very favorable for the examination of the north polar regions, that pole being inclined considerably toward the earth, and the opposition occurring after the midsummer of the northern hemisphere of Mars, so that the polar snows were largely melted and the ice cap reduced to a minimum. It seems quite reasonable to suppose that these dark streaks may be open channels in the frozen polar sea.

The drawing on the right (Fig. 3) was made by Perrotin at Nice on the evening of June 4, at about three hours later than Schiaparelli's, you will notice. The aspect of the planet seems quite different at first sight, and yet one may recognize several of the same features. The rotation of the planet has carried Kaiser Sea toward the left edge of the disk. Dawes Forked Bay has come toward the center and the large continent of Mädler has come into view on the right. Several of the same canals may be seen, and four of them extend across the sea on the north up to the polar cap. They agree well with those of the other drawing, considering the changed aspect of the planet due to rotation. At the left end of the polar cap is a notch which corresponds with the position of the dusky streak on Schiaparelli's drawing. Perrotin saw a dusky shading between the parallel canals. Whether that is due to the more perfect or less perfect defining power of his telescope I am unable to say. The upper drawings* are produced from sketches by myself with the 11-inch telescope at the Cincinnati Observatory. The one was drawn April 3, 1884, 8:30 to 9:00 P. M., some time after the opposition, so that the phase was quite gibbous. No canals were seen, but the colors of the different portions of the disk were carefully noted and I have attempted to reproduce them without, however, perfect success. The other sketch was drawn March 6, 1886, at midnight, the best observing night I have ever seen, and when

* One of these drawings was reproduced in the November number of the MESSENGER, p. 401. The other, showing no canals, is not reproduced.

the planet was almost exactly at opposition. Two of the canals, Indus and Hydaspes, are distinctly shown and the place of others indicated by a faint shading, although at that time I knew nothing about the canals and did not identify them until a few days ago.

Considerable curiosity has been felt as to the performance of the great Lick telescope and its testimony as to the existence and nature of the enigmatic canals, and, although it was late in the season, two months after the planet's opposition, that the monster eye at Mt. Hamilton was turned upon Mars, its testimony has been neither uncertain nor disappointing. A series of twenty-one drawings made by Messrs. Holden and Keeler during the months of July and August have recently been published. In these many of the canals are shown, closely agreeing with Schiaparelli's chart.

What then are these strange markings, and why have they not been seen before? are questions which naturally arise. The discoveries of Schiaparelli were made with a telescope of only eight inches aperture. Why is it that so many observers armed with more powerful instruments have utterly failed to see them? Partly, perhaps, because their skies were not so transparent as that of Italy; partly because their eyes were not so keen as those of the Italian observer; partly also because the phenomena of the canals are periodic; but more because of lack of persistent, long-continued scrutiny of the planet's disc. Again Mars can be seen well only when near opposition, that is, about two months in the year and his distance at opposition varies from 34,000,000 to 64,000,000 miles because of the ellipticity of his orbit, so that a really favorable opportunity to observe minute details occurs only once in about fifteen years. Also, it is necessary for such observations that the sky of Mars be free from clouds over immense areas, whole continents in fact, and we can judge from terrestrial analogy that such a condition would be rare.

Several ingenious theories have been suggested to account for the canals. We can hardly admit that they are artificial canals constructed by the inhabitants. Their great width of seventy miles or more would prohibit that hypothesis, although we may suppose, with Proctor, those inhabitants to be of gigantic stature. Mr. Proctor suggested (*M. N.*

xlviii, p. 307), that they might be rivers, the duplication being a diffraction effect, when mists hang over the river bed, but in doing so seemed to ignore their most characteristic features, their straightness, their frequent intersections, and the fact that they connect the seas, running from one to the other, and that the duplication is not the separation of the old canal, but the formation of a new one on one or the other side of the first.

M. Fizeau, the eminent physicist of Paris, explains them by the analogy of rifts in glaciers and considers the whole planet involved in a glacial epoch. He is led to this hypothesis by the presence of the dark canal in the north polar cap. Dr. Terby, of the observatory of Louvain, thinks this would necessitate a greater movement in the system of canals than has been observed. He finds no evidence of any change since they were discovered. Dr. Penard, a physicist of Geneva, suggests that the canals are immense fissures in the crust of Mars through which the waters flow from ocean to ocean. The mass of Mars, being about one-eighth that of the earth, has cooled off more rapidly, producing great fissures in the crust extending to a very great depth. Another writer suggests for the very same reason that the canals are ridges or wrinkles in the crust, or, in other words, mountain ranges. There are serious objections to each of these and we are still far from a satisfactory explanation. I am rather inclined to the view that these markings are in part, at least, rivers and chains of lakes, that the continents are low and flat and subject to extensive inundations at certain seasons of the Martial year. It seems possible in this way to account for the variations noticed in many of the markings and there appears to be no inconsistency in supposing evaporation and precipitation to be more rapid and abundant on Mars than upon the earth, because of the smaller force of gravity.

In May last Professor Perrotin announced that a whole continent on Mars, as large as France, had disappeared, being inundated by the neighboring sea. This continent, Libya, is well situated to be subject to floods, being surrounded on three sides by seas and a gulf, and on the other side by canals and a lake. Later the land partially reappeared, but was surrounded by much wider dark bands. Notice on the

drawing by Schiaparelli the darker tint of this land as if the water had not yet all receded.

The next two oppositions of Mars in 1890 and 1892 will be very favorable for observation, and it is to be hoped that the giant telescopes as well as the little ones, will then be applied systematically to the solution of the enigma of Mars.

PHOTOGRAPHS OF NEBULÆ.

A. A. COMMON.

It is not many years since the idea of photographing such objects as nebulæ would have been considered impossible, more particularly by those who know most about the subject. Sir John Herschel, in the correspondence which took place about the making of a large telescope for the Southern Hemisphere, which resulted in the 4-foot reflector at Melbourne, expressed his opinion that photography might be used for getting the positions of stars near nebulæ, in order to assist their delineation by hand; but even he, whose knowledge of the nebulæ and of the powers of photography was so great, does not seem to have indulged in the hope that they would ever be photographed directly, possibly because he knew the great difficulties involved; indeed many years before, one who knew less about nebulæ or photography (at that time quite a new art) had, with the confidence of half-knowledge, expressed quite a different opinion. This man was Dr. Dick (whose charming works are not held in such repute as they deserve, or, at any rate, do not seem to be read as they ought to be), who said, as early as 1845, just after the advent of daguerreotype: "Nor is it impossible that the planets Mars, Venus, Jupiter, and Saturn may be delineated in this way, and objects discovered which cannot be discerned by means of the telescope. It might be perhaps considered as beyond the bounds of probability to expect that even distant nebulæ might thus be fixed and a delineation of their objects produced, which shall be capable of being magnified by microscope. But we ought to consider that the art is yet only in its infancy—that plates of a more delicate nature than those hitherto used may yet be prepared, and that other properties of light may yet be dis-

covered which shall facilitate such designs. For we ought now to see no boundaries to the discoveries of science, and to the practical applications of scientific discovery which genius and art may accomplish." This was a long look ahead at the time; but all that Dr. Dick imagined as possible has since been done.

What may be done, or, rather, what will be done as better processes come to the front it is impossible to say, nor do I wish to discuss this aspect of the question in this short note, but rather to deal with what has been shown to be quite possible, and to make some remarks on what has been recently done, particularly by the MM. Henry and Herr von Gothard; and my excuse for doing so is that so little seems to be known as to what can and what cannot be done of a useful character in this department of astronomical photography, that discussion of the subject seems to be necessary. The photographing of nebulæ is remarkable as being almost the only actually modern achievement of photography; all else we can do now could be done in some form or other soon after the first application of photography to astronomy. It is true that the pictures of stars could not be taken as quickly then as they can now; but stars could be be taken; while all attempts to photograph comets or nebulæ failed or were not persevered in through the apparently hopeless nature of the attempt. We are now enabled to get pictures of the nebulæ that are certainly far superior to any drawings, and, what is of immense importance, with instruments of ordinary or moderate size.

In the practical work of photographing the nebulæ, whose light, as a rule, is so very feeble, the aim has been to collect, as much as possible on the plate; and in order to do this the telescope with the smallest ratio of focal length to aperture has been used, as giving the greatest amount of light on the least surface; and if the image produced on the sensitive film were made up of particles so small as not to affect the shape of the image, it would matter little what the size of that aperture was. But, as it is well known, the particles of silver that gather together to form the image have a sensible size, and by an appearance similar to stippling or mezzotint produce a picture. When this picture is small compared to the particles of silver that form it, detail is

lost; and thus the absolute scale of the picture is a matter of importance.

How far processes will be improved in the direction of reducing the size of the silver particles and giving a perfection to the image that at present it has not, it is not possible to say, though there is a promise of improvement in this direction without loss of sensitiveness.

Pending such a solution of the difficulty, it is of interest to consider at the present time what size of image can be utilized—in other words, what is the least aperture that can be usefully employed in taking photographs of the nebulæ. As in all such discussions one ounce of practice is worth a great weight of theory, it is most satisfactory to appeal at once to fact and experience.

Dr. H. C. Vogel, of Potsdam, gives, in No. 2854 of the 'Astronomische Nachrichten,' a very important note on the recent work of Herr von Gothard in photographing nebulæ with a 10-in. reflector, with some drawings that show in a most unmistakable manner with what effect telescopes of this aperture can be used.

In this paper Dr. Vogel expresses an opinion that the photographs of Her von Gothard taken with his comparatively small instrument show results which far surpass any obtained by eye observation with the largest telescope. He mentions the fact that Herr von Gothard some few years ago discovered by photography a small star within the ring-nebula in Lyra, only a few uncertain observations of this star having been previously made, and describes its continued appearance on the photographic plate though invisible in the largest refractors; although I think that there is some slight mistake here, as the star has always been visible with sufficient optical power, still the fact of getting this star so plainly pictured is not less important. We are not, however, concerned with this, but with the work illustrated and described by Dr. Vogel. Six well-known nebulæ are illustrated on a larger scale by drawings made from the photographs, and these can, in most cases, be compared with existing drawings, and the value of those photographic pictures properly estimated. As it happens I can speak, with some degree of confidence, as to one of these.

This, the spiral nebula in Canes Venatici (G. Catalogue

3572), is a nebula that is most peculiarly fitted to deceive the eye by the shape of the outlying parts; hence the great difference in the various published drawings.

In the course of 1883 I took, with about thirty minutes exposure, a photograph of this nebula with a 3-foot aperture, and got a picture somewhat similar to that obtained by Herr von Gothard, *but with less detail;* I made at the time an examination of most of the drawings mentioned by Dr. Vogel, and can quite bear him out in all he says as to the different ways in which they show this nebula. A point of great interest comes out on examining these photographs mentioned by Dr. Vogel—that is, the peculiar aspect of the knotted parts of the nebula, that look almost like stars, but have quite a different character; but a description of a photograph is almost impossible, and to compare the drawings with it is the only proper way to get a correct idea of the respective values.

During the past year MM. Henry at Paris have taken a picture of the Pleiades that brings some most important features to light, showing that this group of stars is in a mass of nebula. This has been suspected by many observers from time to time, but no one had been able to localize any of the brighter parts that have since been shown by photography, except perhaps an observation made with a 3-foot in 1880, that showed two or three of the brighter portions that have since been shown so beautifully on the photographs of the Brothers Henry; on these latter plates not only were these and other masses more or less intense practically discovered, but the positions of exceedingly small stars are given in a way that cannot be attempted by observation or measurement in the ordinary methods–stars that are far too faint to be visible except in the largest telescopes, and even with these not susceptible of accurate measurement. In this particular case I had some years ago observed several exceedingly faint stars near Alcyone that were just visible with a 3-foot reflector, and all of these, with one exception, are shown on the photograph referred to, taken with a photographic telescope of 13 inches aperture.

Similar photographs of the Pleiades have also been taken by Mr. Roberts, near Liverpool, that show almost as much as the photographs of the MM. Henry; but if one can judge

by a comparison of the beautiful engraving of the photographs taken at Paris, with the paper tints of those taken by Mr. Roberts, with less distinctness, particularly as to the peculiar line of light, or rather lines of light so well marked in the Paris photographs. The work of Mr. Roberts was done with an 18-inch silvered glass reflector, and with a shorter exposure than in the other cases.

In the case of the photographs of Herr von Gothard, the exposure was necessarily extended to over two hours, and in the case of the Henrys' photograph to four hours; but length of exposure is of minor importance when we know that once the photograph is secured it is an actual representation that can be afterwards dealt with at leisure and measured, giving then all the results that can be obtained by eye with an instrument far more powerful than that employed. The use of large telescopes will always be in such work of great value, no matter how processes may be improved upon, as the advantage will still be with them, when minute details of structure possibly hitherto unsuspected will be brought out; but even at the present time we can see from the work that has already been done that we need not look to these large telescopes alone; and as the number of known nebulæ is already so great, there is an amount of work to be done that will occupy any possible number of observers for many years if only in getting impressions on such a scale as those obtained by Herr von Gothard: improvement may come afterwards; but improvement can only follow actual work done.

The work of Herr von Gothard is a solid contribution to our practical knowledge of nebular photography, and goes a long way towards settling the capabilities of a certain aperture. Many other questions remain, and it is to be hoped that observers, encouraged by the remarkable success of Herr von Gothard, will do what they can by actual experiment with the means at their disposal, whatever those means are, to throw more light on this most interesting subject.

How far the great expense of large instruments and the increased difficulty of working them are compensated by the larger scale on which the photographs will be obtained; how far it will be advisable to increase the focal length of

moderate apertures to get a larger scale at the expense of longer exposure; to what extent it is advisable to go in the other direction and increase the aperture beyond what is usual even now; how much will be gained by the use of orthochromatic plates or of special plates for special nebulæ; what is the best kind of clock to employ and the best means of giving intermittent exposures,—all these and many other questions will come up for discussion next year when those interested will meet for that purpose. A good deal is becoming known, it is true; but many no doubt thought that 10 inches was much too small an aperture to attempt serious work, and in the same way there may be wrong ideas as to the insufficiency of their means preventing men joining in this work. With Herr von Gothard's example before them they should accept nothing till it is put to the proof of experiment, and by this mean we should soon have a fair knowledge not only of what can be done, but of (what is almost equally important if it has been proved) what cannot be done.—*Observatory*.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury may be seen in the southwest, about an hour after sunset, for about ten days in the latter part of January and first of February. He will be at greatest elongation east from the sun, 18°22′, Jan. 30, at a greater brilliancy the next day; in perihelion Feb. 2, in conjunction with the moon, 4°14′ north, Feb. 1, 10:38 A. M., and at inferior conjunction with the sun, 3°29′ north, Feb. 14, 6:58 P. M.

Venus will cross the First Meridian and the equator on Feb. 1, passing through the constellation of Pisces. No one can fail to recognize her in the early evening, as the most conspicuous object in the whole sky, excepting the moon. Her disc is slightly gibbous, the illuminated part of the equatorial diameter being 0.661 on Jan. 16 and 0.530 on Feb. 15. The declination and consequently the altitude of the planet when near the meridian is rapidly increasing, while at the same time the distance from the earth is decreasing, so that the next two months will afford excellent

opportunities for study of any markings which may be visible on the planet's surface.

Mars although receding from the earth still keeps at nearly the same apparent distance from the sun so that he sets at nearly the same time every night, a little after 8 P. M. He may be found easily among the faint stars of Aquarius, about half way between the southern edge of the Square of Pegasus and the first magnitude star Fomalhaut, and from five to fifteen degrees west of Venus.

Jupiter rises from two to three hours earlier than the sun, but at such a low declination that it is hardly worth the while for northern observers to attempt any observations of his surface or satellites.

Saturn will be at opposition to the sun Feb. 4 so that the two months of January and February will be the best, so far as position is concerned, for observations of that planet. To find Saturn in January at 8 P. M. look toward the east and a little to the north; the brightest star near the horizon is Saturn. Above him, half way or more to the zenith one will recognize the two stars of The Twins, Castor and Pollux; to the right from them another pair, one star brighter than the other, Procyon and his comrade in the Little Dog; still farther to the right another similar pair, one of which is the magnificent Sirius the brightest of all the starry host; and to the right and north of these, that most splendid of all constellations, Orion. A little later the Sickle of the constellation of Leo will be seen above the eastern horizon and Saturn may be recognized as the yellow star just above th eSickle about equidistant from its extremities.

Uranus may be found after midnight in the constellation of Virgo about 3° north of Spica almost on a line between Spica and ζ Virginis.

Neptune is about 5° south and a little east of the Pleiades which are on the meridian at half past eight P. M. Jan. 15. There are but two or three stars as bright as Neptune within a radius degree or more, so that the task of identifying the planet, with a telescope of 4 or more inches aperture, provided with only rough circles, will not be very great.

MERCURY.

	R. A. h m	Decl.	Rises. h m	Transits. h m	Sets. h m
Jan. 25	21 43.6	−14°26′	8 18 A. M.	1 22.6 P. M.	6 28 P. M.
30	22 06.0	−11 19	8 07 "	1 25.1 "	6 43 "
Feb. 4	22 16.0	− 8 55	7 47 "	1 15.4 "	6 44 "
22	22 10.1	− 8 06	7 19 "	0 50.0 "	6 21 "
14	27 51.4	− 9 03	6 44 "	0 11 6 "	5 39 "

VENUS.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	23 28.8	− 3 50	9 19 A. M.	3 07.3 P. M.	8 55 P. M.
Feb. 4	0 08.2	+ 1 18	8 59 "	3 07.3 "	9 16 "
14	0 45.6	+ 6 21	8 37 "	3 05.3 "	9 34 "

MARS.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	22 57.0	− 7 36	9 02 A. M.	2 36.0 P. M.	8 09 P. M.
Feb. 4	23 25.6	− 4 29	8 40 "	2 25.2 "	8 11 "
14	23 53.7	− 1 20	8 15 "	2 13.7 "	8 12 "

JUPITER.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	17 50.5	−23 05	5 05 A. M.	9 29.8 A. M.	1 55 P. M.
Feb. 4	17 59.0	−23 06	4 34 "	8 59.0 "	1 24 "
14	18 06.9	−23 06	4 02 "	8 27.6 "	12 56 "

SATURN.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	9 22.2	+16 36	5 48 P. M.	12 59.1 A. M.	8 11 A. M.
Feb. 4	9 19.0	+16 52	5 04 "	12 16.6 "	7 29 "
14	9 15.8	+17 07	4 20 "	11 34.1 "	6 48 "

URANUS.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	13 22.3	− 7 59	11 27 P. M.	4 58.5 A. M.	10 30 A. M.
Feb. 4	13 22.0	− 7 57	10 47 "	4 19.0 "	9 51 "
14	13 21.5	− 7 54	10 07 "	3 39.1 "	9 11 "

NEPTUNE.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	3 50.9	+18 25	12 09 P. M.	7 28.7 P. M.	2 48 A. M.
Feb. 4	3 50.8	+18 25	11 28 "	6 48.2 "	2 08 "
14	3 50.8	+18 26	10 50 "	6 09.9 "	1 30 "

THE SUN.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 20	20 12.7	−19 57	7 30 A. M.	12 11.5 A. M.	4 53 P. M.
25	20 33.7	−18 46	7 26 "	12 12.7 "	5 00 "
30	20 54.3	−17 26	7 20 "	12 13.6 "	5 07 "
Feb. 4	21 14.6	−16 00	7 15 "	12 14.2 "	5 14 "
9	21 34.6	−14 25	7 08 "	12 14.5 "	5 21 "
14	21 54.2	−12 45	7 01 "	12 14.4 "	5 28 "

Occultations Visible at Washington.

			IMMERSION.		EMERSION.		
Date.	Star's Name.	Magnitude.	Wash. Mean T. h m	Angle f'm N. P't. °	Wash. Mean T. h m	Angle f'm N. P't. °	Duration. h m
Feb. 8	δ^1 Tauri	4	13 20	42	14 03	304	0 43
8	δ^2 Tauri	5½	13 45	76	14 39	271	0 54
11	*d* Geminorum	6	11 07	69	12 20	303	1 13
14	83 Cancri	5½	4 38	6	Star 0.7′ N. of moon's limb.		
14	8 Leonis	5½	14 53	73	15 46	333	0 52
15	37 Leonis	5½	6 52	131	7 49	256	0 56

Phases of the Moon.

	Central Time. d h m
Full Moon	Jan. 16 11 37 P. M.
Last Quarter	" 24 9 57 P. M.
New Moon	" 31 3 10 A. M.
First Quarter	Feb. 7 2 58 P. M.
Full Moon	" 15 4 17 P. M.

Elongations and Conjunctions of Saturn's Satellites.

[*Central Time; E = Eastern elongation, W = Western elongation, S = Superior conjunction, I = Inferior conjunction.*]

JAPETUS.

d		d	
Jan. 29,	I	Feb. 17,	W

TITAN.

d h		d h		d h	
Jan. 17, 8 A. M.	I	Jan. 29, 6 A. M.	E	Feb. 10, 4 A. M.	S
21, 7 A. M.	W	Feb. 2, 5 A. M.	I	14, 3 A. M.	E
25, 6 A. M.	S	6, 4 A. M.	W		

RHEA.

d h		d h		d h	
Jan. 16, 10.2 A. M.	E	Jan. 29, 11.0 P. M.	E	Feb. 12, 11.8 A. M.	E
20, 10.5 P. M.	E	Feb. 4, 11.3 A. M.	E		
25, 10.8 A. M.	E	7, 11.7 P. M.	E		

DIONE.

d h		d h		d h	
Jan. 16, 5.4 A. M.	E	Jan. 27, 3.9 A. M.	E	Feb. 7, 2.4 A. M.	E
18, 11.0 P. M.	E	29, 9.5 P. M.	E	9, 8.0 P. M.	E
21, 4.6 P. M.	E	Feb. 1, 3.1 P. M.	E	12, 1.6 P. M.	E
24, 10.2 A. M.	E	4, 8.7 A. M.	E	15, 7.2 A. M.	E

TETHYS.

d h		d h		d h	
Jan. 16, 9.2 A. M.	E	Jan. 27, 4.9 P. M.	E	Feb. 8, 12.5 A. M.	E
18, 6.5 A. M.	E	29, 2.1 P. M.	E	9, 9.8 P. M.	E
20, 3.8 A. M.	E	31, 11.4 A. M.	E	11, 7.1 P. M.	E
22, 1.1 A. M.	E	Feb. 2, 8.7 A. M.	E	13, 4.3 P. M.	E
23, 10.3 P. M.	E	4, 6.0 A. M.	E	15, 1.6 P. M.	E
25, 7.6 P. M.	E	6, 3.2 A. M.	E		

A Partial Eclipse of the Moon will occur on Jan. 16, 1889. It will be visible in the United States and generally in Europe, Africa, North and South America, and the Atlantic and Pacific Oceans. The following are the times of the phases:

	Washington Mean Time. d h m	Central Time. d h m
Moon enters penumbra	Jan. 16, 9 29.3	Jan. 16, 8 37.5 P. M.
Moon enters shadow	10 50.0	9 58.2 P. M.
Middle of eclipse	12 21.5	11 29.7 P. M.
Moon leaves shadow	13 53.0	17, 1 01.2 A. M.
Moon leaves penumbra	15 13.5	2 21.7 A. M.

The magnitude of the eclipse, or the portion of the disc covered, will be 0.702. First contact of the shadow with the edge of the moon will occur at a point 133.3° east from the north point of the disc and last contact at a point 122.0° west from the north point of the moon's disc.

Instructions for the January Eclipse. Professor David P. Todd, Director of the Amherst College Observatory, also prepared a pamphlet of instructions for those intending to observe the total eclipse of January 1. The proof sheets have been received. The details of these instructions have been carefully worked out, and will prove helpful to persons availing themselves of them.

Ephemeris of Comet e 1888 (*Barnard*). The following ephemeris is taken from *A. N.*, No. 2867:

1889	α app.	app.	log. r	log. Δ	L.
	h m	° ′			
Jan. 1	17 40	−7 16.4			
" 2	15 48	7 13.2			
" 3	14 2	7 9.9			
" 4	12 20	7 6.5	0.2664	0.2633	5.0
" 5	10 42	7 3.0			
" 6	9 9	6 59.3			
" 7	7 40	6 55.6			
" 8	6 14	6 51.8	0.2644	0.2850	4.6
" 9	4 52	6 47.9			
" 10	3 33	6 43.9			
" 11	2 18	6 39.8			
" 12	1 6	−6 35.8	0.2626	0.3053	4.2

Ephemeris of Faye's Comet 1888 IV. The following ephemeris is also found in *A. N.*, No. 2867, and for the month of January, computed by E. Lamp:

1889	α app.	δ app.	log. r	log. Δ	L.
	h m s	° ′			
Jan. 1	8 1 5	+0 10.2			
" 3	7 59 28	0 10.9	0.3330	0.0896	1.67
" 7	56 6	0 15.8	0.3372	0.0927	1.62
" 11	52 40	0 25.0	0.3414	0.0970	1.56
" 15	49 16	0 38.2	0.3455	0.1026	1.49
" 19	45 59	0 55.3	0.3497	0.1095	1.42
" 23	42 52	1 15.6	0.3538	0.1176	1.34
" 27	39 59	1 38.8	0.3580	0.1267	1.26
" 31	37 25	+2 4.1	0.3621	0.1367	1.18

Comt f 1888 (*Barnard*). We have not received the ephem-emeris of Comet *f* for January, 1889, and hence can only give the last ten days of December, as follows:

1888.	α app.	δ app.	log. r	log. Δ	L.
	h m s	° ′			
Dec. 22	10 26 54	−1 35.3	0.3100	0.1634	0.92
" 23	26 53	1 10.0			
" 24	26 50	0 44.2			
" 25	26 45	−0 18.0			
" 26	26 36	+0 8 7	0.3176	0.1577	0.91
" 27	26 26	0 35.7			
" 28	26 14	1 3.2			
" 29	26 0	1 31.1			
" 30	25 43	1 59.6	0.3251	0.1527	0.90
" 31	10 25 24	+2 28.6			

The Discovery of the Planet Uranus. [The Philosophical Transactions for 1781 contains a letter from Sir William Herschel announcing the discovery of a comet [U*ranus*], and as that volume is not within reach of hundreds of the readers of THE SIDEREAL MESSENGER, I have thought

that extracts from Herschel's letter would be interesting to those readers.] H. P. T.

ACCOUNT OF A COMET BY MR. HERSCHEL, F. R. S., READ APRIL 26, 1781.

"On Tuesday, the 13th of March, between ten and eleven in the evening, while I was examining the small stars in the neighborhood of H Geminorum, I perceived one that appeared visibly larger than the rest; being struck with its uncommon magnitude, I compared it to H Geminorum and the small star in the quartile between Auriga and Gemini, and finding it so much larger than either of them, suspected it to be a comet.

"I was then engaged in a series of observations on the parallax of the fixed stars which I hope soon to have the honour of laying before the Royal Society; and those observations requiring very high powers, I had at hand the several magnifyers of 227, 460, 932, 1536, 2010, etc., all of which I have successfully used upon that occasion. The power I had on when I first saw the comet was 227. From experience I knew that the diameters of the fixed stars are not propotionally magnified with the high powers as the planets are; therefore I put on the powers of 460 and 932, and found the diameter of the comet increased in proportion to the power, as it ought to be, on the supposition of its not being a fixed star, while the diameters of the stars to which I compared it were not increased in the same ratio. Moreover, the comet being magnified much beyond what its light would admit of, appeared hazy and ill defined with these great powers, while the stars preserved that luster and distinctness which from many thousand observations I knew they would retain. The sequel has shown that my surmises were well founded, this proving to be the comet we have lately observed.

"I have reduced all my observations upon this comet to the following tables: The first contains the measures of the gradual increase of the comet's diameter. The micrometers I used, when every circumstance is favorable, will measure extremely small angles, such as do not exceed a few seconds, true to 6, 8, or 10 thirds at most; and in the worst situations true to 20 or 30 thirds; I have therefore given the measures of the comet's diameter to seconds and thirds. And the parts of my micrometer being thus reduced,

I have also given all the rest of the measures in the same manner; though in large distances, such as one, two, or three minutes, so great an exactness, for several reasons, is not pretended to." * * * [Then follow Herschel's measurements of the "comet's" diameter and remarks on the physical appearance of the "comet."]

"*March 19.* The comet's motion is at present 2¼ seconds *per* hour. It moves according to the order of the signs, and its orbit declines but little from the ecliptic.

"*March 25.* The apparent motion of the comet is accelerating, and its apparent diameter seems to be increasing.

"*March 28.* The diameter is certainly increased, from which we may conclude that the comet approaches to us.

* * * * * * * * * *

"*April 6.* With a magnifying power of 278 times the comet appeared perfectly sharp upon the edges, and extremely well defined, without the least appearance of beard or tail." * * * [Here follow a page of "remarks on the path of the comet," and several pages of diagrams of stars in the vicinity of the "comet." About this time Dr. Maskelyne, astronomer royal, began observations of the "comet" and Herschel appears to have dropped the matter until the following October. In the mean time the French astronomer had determined the true nature of the mysterious body.]

Queries and Answers. 12. It is difficult to say why text-books on Astronomy do not more generally notice the fact, that there is precession in the *declination* of the stars, as well as in *right ascension*, which is commonly spoken of. In some instances we presume that the writers leave that fact to be inferred from statements like the following: Since the position of ecliptic among the stars is well-nigh invariable the latitude of the stars does not change, but the declination, right ascension and longitude do change.

J. A. B. thanks the MESSENGER and Mr. Brennan and in return gives an answer to question 14 in November number, "How is the oft repeated statement made by astronomers explained, that the sun attracts a comet, and at the same time repels it to form its tail? How can the sun simultaneously attract and repel?

Miss Clerke in "Astronomy in the Nineteenth Century," page 385, says:

"It is perfectly well ascertained that the energy of the push or pull produced by electricity depends (other things being the same) upon the *surface* of the body acted on; that of gravity upon the *mass*. The efficacy of solar electrical repulsion relatively to solar gravitational attraction grows, consequently, as the size of the particle diminishes. Make this small enough, and it will virtually cease to gravitate, and will unconditionally obey the impulse to recession.

"This principle Tolluer was the first to realize in its application to comets. It gives the key to their constitution. Admitting (as we seem bound to do) that the sun and they are similarly electrified, their more substantially aggregated parts will still follow the solicitation of his gravity, while the finely divided particles escaping from them will simply, by reason of their minuteness, fall under the sway of his repellant electric power. They will, in other words, form "tails." Nor is any extravagant assumption called for as to the intensity of the electrical charge concerned in producing there effects. Tolluer, in fact, showed that it need not be higher than that attributed by the best authorities to the terrestrial surface."

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15. If a ball be fired from a zenith pointing gun to a great height, in falling it will strike the earth to the *west* of the point of projection. If the same ball be dropped from rest, from the same height, it will fall *eastward* of the vertical at the point of starting. In the former case the ball will reach the earth twelve times as far to the *west*, as, in the latter case, it does to the *east*. The following equations show this:

$$\eta = 8s \sqrt{\frac{2s}{g}}\, n \cos \varphi.$$

$$\eta = -\tfrac{2}{3}s \sqrt{\frac{2s}{g}}\, n \cos \varphi.$$

In which η means *westerly* direction of deviation, the minus meaning east, g, force gravity, s, greatest height, n, angular velocity of rotation and φ, the latitude of the place. The formulæ are perfectly general and show that the deviation of bodies falling from great heights, or projected upward and falling, would not deviate at all from the vertical at the poles of the earth.

Comet Faye. We learned by Science Code telegram that Faye's comet was observed at Nice, Dec. 3.7119 in

R. A. 8*h* 12*m* 31.3*s*.

Decl. $+2^\circ\ 21'\ 02''$.

This comet has been regularly observed at Lick Observatory.

EDITORIAL NOTES.

This number is closed a few days earlier than usual, in order to give the editor an opportunity to visit California, and observe the total eclipse of the sun, which occurs Jan. 1, 1889.

It is believed that it will be possible to give a pretty full account of the observations of the total eclipse in our next issue, though it will be too early for best information or final results of some important work that may be done.

In our class in College Astronomy during the last three months, we have used the proof sheets of Professor C. A. Young's new General Astronomy with great satisfaction. This book contains 550 pages with 250 illustrations, and will be ready for the purchaser in complete form Jan. 1. All teachers of astronomy will certainlv be interested in examining this new book. Its introduction price is $1.80.

Professor Holden's pamplet of suggestions for observing the total eclipse of the sun Jan. 1, is a very useful and timely document. He deserves the thanks of the multitude of visitors, home and foreign, who will be on the mountains and the Pacific slope to observe Luna's dark compliments for the New Year's Day of 1889.

New Nebulæ by Photography. At Harvard College Observatory, new nebulæ have recently been detected by photography. The objective of the instrument employed is called a photographic doublet instead of an ordinary photographic objective. The advantages of the doublet are increase of field and of angular aperture, and these give about double the light energy for the sensitive plate over that of the ordinary photographic objective. The time of exposure is therefore correspondingly diminished. This is a great advantage in photographing objects in moonlight, or faint objects like many of the nebulæ. The results of work done in this way are determined by comparing the photographic plates with catalogues of nebulæ and so ascertaining what objects are new.

Each plate is laid on a frame inclined at an angle of 45°, and the light of the sky reflected through it by means of a horizontal mirror. Each portion of the plate is then studied with a magnifying glass, and the co-ordinates of every object resembling a nebula are measured. The approximate right ascensions and declinations of these objects are next determined from the configuration of the adjacent stars on the charts of the Durchmusterung, which are on the same scale of two centimeters to a degree. A comparison is next made of all the objects detected on any of the plates. The results of these comparisons are tabulated and new objects are easily known. The Batche telescope has an objective of 8 inches aperture and 44 inches focal length, and is a doublet as before described. Its photographic field of good definition is seven degrees in diameter, though each plate covers a region of ten degrees square. Trial of this method was made of the region of the sky with the great nebula of Orion as a center, and twelve nebulæ were found that were probably new. This is most encouraging progress in photography. It looks as if some of our American workers were rivaling the noble skill of von Gothard and the Henry brothers.

Comet e 1888. O. C. Wendell, of Harvard College Observatory, kindly sent the ephemeris of comet *e* (Barnard) for December, to the MESSENGER, rightly addressed and in time, but the letter visited one or more of the other numerous Northfields in the United States, so that it did not finally reach us in time. We have elsewhere given the last nine days of December because we mail so much earlier than usual.

We take great pleasure in presenting to our readers a cut and description of the new Meridian Circle, recently made by Messrs. Fauth & Co. of Washington, D. C., for Cincinnati Observatory. As far as is now known it is the finest instrument of the kind of American make in this country. We shall not be surprised if it prove equal to the best that even distinguished foreigners can produce. Messrs. Fauth & Co. are to be congratulated in this forward and difficult step of undertaking to make large, fine meridian instruments.

The Canals of Mars. In a late report of work going on at the Lick Observatory, Professor Holden says: "The season for making observations of the canals of Mars was in April and May of this year (1888). Owing to the delays in completing the Lick Observatory no observations could be made here until July.

"From that time until the latter part of August the planet was diligently followed, over forty careful drawings having been made. These drawings show at least twenty of the principal "canals," but no one of them was seen doubled. The submerged "continent" had reappeared also and was seen by us here, essentially as it had always appeared since 1877. It was most unfortunate that the Lick telescope could not be used for this purpose until so late a date; but it has shown its great power in such work by following the fine details on the surface two months later than other instruments, and it has conclusively proved that whatever may have been the condition of the "continent" previous to July, it was certainly in its normal condition from that time onward "

Seven Eclipses in one Year. In one of the text books of astronomy I read some time ago that the greatest number of eclipses that could possibly occur in one year is seven, and the least number is two; and that neither happens oftener than twice in a century.

This is greatly erroneous as regards the least number; two eclipses in a calendar year are of frequent occurrence; it happens three or four times in every 18-year period; but seven eclipses *in one calendar year* are of very rare occurrence. I have a pretty full list of eclipses for the past one hundred years, and I greatly doubt if there has been a year with seven eclipses in all that period.

Perhaps some of your readers may feel like investigating and letting us know *when* there were seven eclipses in one year, and when this will occur again. But seven eclipses *in a year's time* are not unfrequent. In Loomis's Astronomy are given examples illustrating the principle in connection with the 18-year period, beginning with eclipses in 1768–69, and running until 1894–96. There were seven eclipses from Feb. 12, 1877 to Feb. 1, 1878. In 1894, 1895 and 1896 occur the following:

Date.	Eclipsed.	Date.	Eclipsed.
Sept. 15, 1894	Moon.	Aug. 20, 1895	Sun.
Sept. 29, 1894	Sun.	Sept. 4, 1895	Moon.
Feb. 24, 1895	Sun.	Sept. 18, 1895	Sun.
Mar. 11, 1895	Moon.	Feb. 13, 1896	Sun.
Mar. 26, 1895	Sun.	Feb. 28, 1896	Moon.

Which gives us the following remarkable clusters of eclipses:

Date.	Ecl.	Date.	Ecl.
Sept. 15, 1894, to Sept. 4, 1895	7	Feb. 24, 1895, to Feb. 13, 1896	7
Sept. 29, 1894, to Sept. 18, 1869	7	Mar. 11, 1895, to Feb. 28, 1896	7

But it is of more interest, possibly, to remark that seven eclipses in a year's time are now in progress, viz.:

Date.	Eclipse.	Date.	Eclipse.
June 28, 1888	Moon.	Aug. 7, 1888	Sun.
Feb. 11, 1888	Sun.	Jan. 1, 1889	Sun.
July 9, 1888	Sun.	Jan. 16, 1889	Moon.
July 22, 1888	Moon.		

St. Louis, Nov. 17, 1888. F. H. BURGESS.

Mr. J. E. Gore, Vice President of the Liverpool Astronomical society, has computed the orbits of two binary stars with following results:

Struve, 2120:

$$\rho^2 = 4.9729 + 0.0225\ (t - 1850.4)^2$$
$$\text{Sec}\ (317^\circ.20 - \theta) = 0.4484\ \rho.$$

45 Geminorum, $O\Sigma$ 165:

$$\rho^2 = 8.352 + 0.0093\ (t - 1873.55)^2$$
$$\text{Sec}\ (87^\circ.90 - \theta) = 0.346\ \rho.$$

The computed and observed places for the first for more than 100 years compare well. Those of the second extend over a period of 40 years.

J. E. Gore's Revised Catalogue of Variable Stars. May 12, 1884, Mr. Gore read a paper before the Royal Irish Academy under the title of "A Catalogue of suspected variable stars," which contained 736 such stars, and 114 pages of notes and observations. A neat two page map of the heavens also accompanied that paper showing the distribution of the known and the suspected variables. The known stars were printed red, the suspected, black, the right ascension and declination of each being read easily at sight.

We have now before us a revised catalogue of variable stars by the same author, it being a paper read before the Irish Academy Dec. 12, 1887. It is thought to contain all stars now certainly known to vary in light, including recent discoveries with positions brought down to 1890.0. The former catalogue contained the number, name, place for 1880, change of magnitude and authority. This one

adds maximum and minimum of magnitude with dates for each, mean period in days, color and spectrum. We were not before aware of the existence of this important paper. We commend it to our readers.

Wolsingham Observatory. Communications intended for Wolsingham Observatory should hereafter be addressed Towlaw, Darlington, England. The site of the new Observatory is three miles northeast of the old one, and stands 1,000 feet above the sea. T. E. Espin is in charge.

Asteroid 281. The following circular elements of Asteroid 281 have been computed from the very simple formulæ given by Oppolzer in his *Lehrbuch*, vol. i (2d ed.) p. 447-452, using the discovery position of Oct. 31 and a Washington observation of Nov. 3:

Epoch: 1888, Oct. 31.5165 Gr. M. T.

$$\left.\begin{aligned} u &= 3^\circ 24'.1 \\ \Omega &= 32\ 15\ .8 \\ i &= 10\ 18\ .8 \end{aligned}\right\} \text{True equinox of epoch.}$$

$$\mu = 926''.9$$

$$\log. a = 0.38864$$

An ephemeris derived from these elements represents the position of the asteroid on Nov. 13 within 16*s* in right ascension and 0′.2 in declination. W. C. W.

In query No. 17 E. W. A. asks, "What is a dialytic telescope?" The ordinary meaning of that phrase is: "An achromatic telescope in which the colored dispersion produced by a single object lens of crown glass is corrected by a smaller concave lens, or combination of lenses, of high dispersive power, placed at a distance in the narrower part of the converging cone of rays, usually near the middle of the tube." A practical article entitled "Astronomical Telescopes, Their Object Glasses and Reflectors," by G. D. Hiscox, is to be found in Nos. 581, 582 and 583 of the *Scientific American Supplement*. These can be had at any time from the publishers of that paper. No. 582 treats upon the dialyte, and gives much information as to their construction and the principles involved. ***

Our readers certainly ought to enjoy with us some of the racy, off-hand good things of one of our royal correspondents from the other side of the water. The other day we had reason to believe that we had wrongly addressed a letter to our genial friend, C. Piazzi Smyth, or had, inadvertently, done some other equally bad thing, and so we asked him about it. From a prompt private letter we take part of his answer as follows: "But we are strangely in the dark as to addresses. You ask me in your postscript touchingly 'Will you not kindly give me your present address.' I reply, most certainly I will. 'Clova,' as above, is the name of the little house which my wife and I inhabit and own. 'Ripon' is the name of the little town, 1,000 years old as a municipality, but only numbering as yet 7,000 inhabitants, within five minutes walk of whose central market place the above little house of Clova is situated, and is yet a country-house in a garden and green field. Within all Great Britain there is not another town of the same name; so that for all home letters 'Clova, Ripon,' is quite enough post office address. But for those, as yourself, beyond the seas it is necessary that you should add thereto "*England*." So you see I have left Scotland as well as retired from the Astronomer Royalship thereof. You, or your part, do *not* give me the address of your nearest British money-order-paying office. Partly, perhaps, because you seem over generously to imply, that because it turns out that I had paid subscriptions for the Royal Observatory Edinburgh, to the SIDEREAL MESSENGER for two former years, you would let the present year go free. But that I cannot allow; I have therefore just walked into Ripon and obtained a money order for eight shillings British ($2 American, I suppose), payable to you by name, but at no nearer post office than St. Paul, Ramsey County, Minnesota. This I accordingly enclose and I hope you will be able to negotiate it without much trouble. Your last number I have sent to the Royal Observatory, Edinburgh, and if you will kindly send the next one there also, you will have accomplished your whole duty. I may then wait to see if my successor is as fully aware, as I have been, of the great advantage of being "in touch" with the rising American Astronomers.

I am more bent at present in trying to complete a great

work on spectroscopy than any thing else, if health and life also hold out; but that will be as God planned from the beginning. I remain still admiring your excelsior struggles."

Queries. 18. When does the next century begin? Wrongly answered in the *Scientific American* recently.

19. Why does the full moon run high in winter and low in summer?

20. There is daily increase in the right ascension and the declination of the stars. It is irregular in both; is it periodical in one or both? A. B. C.

21. What are the properties of the new glass that make it superior to the old? G. H. P.

22. Is not the statement in the text books on astronomy that sunlight is 800,000 times greater than full moon-light manifestly wrong? Common observation would say that number is 1,000 times greater than it should be? I. C.

23. As a result of a long series of experiments conducted with the utmost skill and care, Professor Langley estimates that if the atmosphere were removed from the earth the temperature of the soil in the tropics, under a vertical sun would be reduced far below zero, probably down to—328 Fahr. On page 123, Professor Loomis' College Astronomy states that the extremes of temperature on the moon must be very violent. During the period of the sun's shining the surface must become intensely heated; and during the next fortnight the cold must be equally severe. Which is right? F. H.

Where the Eclipse Parties Observe. By referring to our map of the path of totality of the eclipse, published in the last MESSENGER those interested may learn the location of each of the observing parties, so far as we know them at present.

Dr. Lewis Swift, near Chico, California. He will observe for intra-Mercurial planets.

Charles S. Rockwell, of Tarrytown, New York, will observe at some point in California.

The Lick Observatory will send a party to a station in Lake County in charge of Mr. Keeler. Mr. Keeler will use the 6-inch equatorial of the observatory and a spectroscope (kindly lent for the occasion from the apparatus of the Chabot Observatory by Hon. Fred M. Campbell) for the

purpose of testing the theory proposed by Professor Hastings of Yale College to account for the phenomena of the solar corona—namely, that it is chiefly due to the diffraction of the solar rays at the edge of the moon. Mr. Barnard of the Observatory, will have entire charge of the photographic observations of the corona. Mr. Hill of the Observatory, will observe the contacts and assist Mr. Keeler. Mr. Leuschner, student of astronomy, will probably make photometric observations to determine the relative light of the corona and the full moon. At the Lick Observatory the eclipse will be partial, not total. The contacts will be observed by Professor Holden, Mr. Burnham and Mr. Schaeberle, and a series of photographs of the various phase swill be made with the photoheliograph.

Under the enthusiastic direction of Mr. Burckhalter of the Chabot Observatory a great number of members of the Pacific Coast Association of Amateur Photographers intend to photograph the corona. If the day is fair it is almost certain that the plans adopted by these gentlemen will produce extremely valuable results.

A party from Harvard College Observatory will take station at Willows. The party is to consist of Professor W. H. Pickering, chief; A. L. Rotch, the meteorologist; Mr. Bailey, Mr. King and Mr. Black. The work of the party is the photography and photometry of the corona.

It is understood that Professor Lewis Swift, Director of the Warner Observatory of Rochester, N. Y., will search for intra-mercurial planets at some station in the Sacramento Valley.

Professor J. P. D. John, Director of the De Pauw Observatory of Greencastle, Ind., with his assistant, Dr. W. V. Brown, will probably occupy a station somewhere in Butte or Plumas counties. The equipment of this party consists of two 5-inch telescopes, an almucanter, etc.

Professor H. S. Pritchett, Director of the Observatory of Washington University of St. Louis, Mo., proposes to observe the eclipse by photography at a station not yet chosen.

Mr. Blinn will take some of the instruments of his private observatory in East Oakland to a station at or near Winnemucca, Nev.

In Nevada, also, United States Surveyor General Irish, who is practiced in astronomy, intends to make observations of the eclipse.

Professor W. Upton of Brown University, Providence, R. I., with observers from Blue Hill will seek a position in Western California for observation.

A party of observers from Carleton College, Northfield, Minn., cosisting of Professors Payne, Pearson and Wilson will probably observe the eclipse either in western Nevada or at Chico, California. Their instruments are a 6-inch reflector for photography, a 4-inch refractor, a zenith telescope and other lesser apparatus.

Lorenzo Kropp, of Paysandú, Uruguay, South America, in a recent private letter, gives useful information concerning the irregularity of the mails between the United States and parts, at least, of South America; but he says the European mails are always received with great regularity. This is the second instance that subscribers to the MESSENGER in South America have suggested that their copies should be mailed *via* England.

We are pleased to know that Mr. Kropp has a 5-inch Refractor by Reinfielder and Hertel, of Munich ,and that we are soon to hear of its quality and work.

E. F. Swayer of Cambridgeport, Mass., has given an important series of observations on suspected variable stars in the *Astronomical Journal*, No. 184. There are 33 such stars to which attention is called.

BOOK NOTICES.

An Elementary Treatise on Ayromechanics, with Numerous Examples, by Edward A. Bowser, LL. D., Professor of Mathematics and Engineering in Rutgers College. Second Edition. New York: D. Van Nostrand, publisher, 23 Murray and 27 Warren Street; 1886.

This book was written three years ago, and designed to follow the author's work in Analytic Mechanics noticed in this magazine a few months ago. Like the Analytic Mechanics, its proofs are by the aid of Analytic Geometry and the Calculus, whichever seems to the author best to use in any given case under consideration.

The work consists of two parts; Hydrostatics and Hydrokinetics. The first contains three chapters and the second four. The first chapter deals with equilibrium and pressure of fluids. In the study of normal pressure successive integration is used, bringing out very neatly the *nature* of fluid pressures, and showing what is often difficult for beginners to understand that the action of a fluid does not depend upon its *quantity*, but on the *position* and *arrangement* of its continuous portions.

The second chapter treats of the equilibrium of floating bodies and specific gravity; and the third of gases and elastic fluid.

The author devotes 162 pages to Hydrokinetics and discusses the resistance and work of liquids, the motion of water in pipes and open canals, the motion of elastic fiuids and hydrostatic and hydraulic machines.

The pratical bearing of this work, and the aim of it, to lead the student to an intellegent use of his mathematical knowledge in useful application, are points of commendation. It is a valuable book for the teacher's table if its scope is beyond his class-room work.

Plan and Spherical Trigonometry, by Alfred H. Welsh, A. M., of Ohio State University. Chicago: Messrs. C. Buckbee & Co., Publishers, 1888; pp. 196.

We always like to get a book from a Chicago printer, because we want to know how those young ambitious people succeed in printing books. It may, probably will, surprise our Eastern friends that Chicago is printing books on the higher mathematics, though we well remember that this is not the first one.

This book begins with a chapter on logarithms to which eighteen pages are devoted. Under each theme or theorem is a table of exercises designed to test the pupil's practical knowledge of the principles enunciated above. In this the author recognizes the need of the class-room, especially for the ordinary pupil before undertaking the operations of trigonometry.

Though there is good authority for defining trigonometric functions as ratios, in practice, we have always found that direct definitions upon the lines themselves, were preferable. The second chapter consisting of 54 pages, treats of the plane triangle in which the use of natural functions in the solution of examples is universally extended. The student, in this part of his work, has only to do with acute angles in the exercises given and this arrangement is designed by the author for the sake of developing the branch properly and obtaining from the student, as he believes, more definite results.

The second step in this book is called Gonometry which is that branch that treats of trigonometric functions in general. Under this head appear a study of the signs of the angles, and lines representing the functions, the general relation between the functions, and the common formulæ for the sum and difference of triangles and other similar ones usually given in such works. The exercises under each head are very good, we could only wish there were more of them. Here are two as specimens:

Given sin $(x+y) = \cos\ (x-y)$ to find x and y.

Adapt to logarithmic computation:

$$\frac{\text{Sin } 68° - \text{Sin } 35°}{\text{Sin } (68° - 35°)}$$

The spherical Trigonometry appears to be equal to that found in the latest and best books, presenting even some for the formulæ for the general spherical triangle. The numerial examples under this head might be increased with profit to the student. The logarithmic table for numbers is 4 places and extends to 200. The table for logarithmic functions is to 10′ and 4 places. The natural table is to 10′ and 5 places. They are in neat form and good type for its size. This book is certainly a credit to the printing house from which it comes.

Numbers Symbolized, an Elementary Algebra, by David M. Seusenig, M. S., Professor of Mathematics. State Normal School, West Chester, Pa. Messrs. D. Appleton & Co., Publishers. New York, Boston, and Chicago, 1888; pp. 315.

This elementary book in the Appleton Mathematical Series has been prepared evidently by a teacher of experience of the best kind. We are pleased to see so much care in stating definitions and elementary principles. We expect that teachers in the best normal schools will know how to put things accurately and well, and usually they do not fail to meet expectations in this regard.

In the earlier pages the graded sequence of development is easy and natural for the beginning pupil, though he be young in years, for evidently such pupils were in the mind of the writer as well as others. After the fundamental operation the simple equation, with one, two and three unknown quantities, is briefly treated, but the burden of exercise for the pupil is in the study of the exponent, the fraction, the radical and the imaginary. This is right; for if a pupil is well grounded in these, from the beginning, he will always study algebra with pleasure and profit. We are sorry to see fractions written, as ⅔, for example.

Should a teacher ever allow a pupil to write a fraction that way? That is a commercial fraud. In method it is both inaccurate and inelegant. But this is a little blemish only on an otherwise excellent book.